



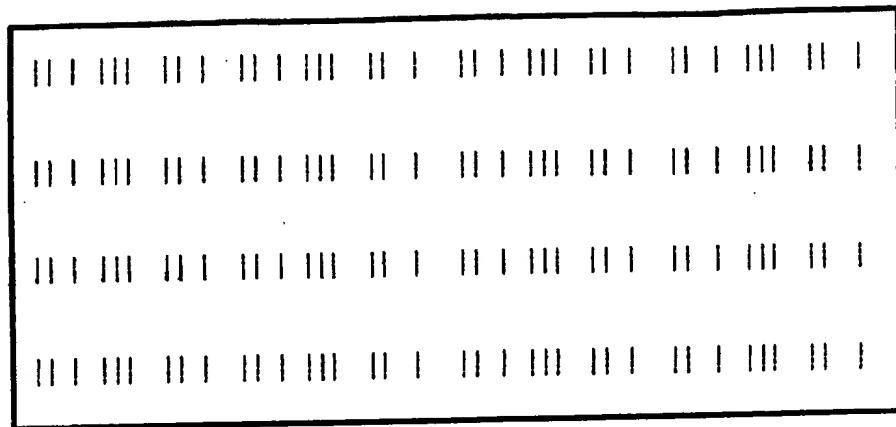
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(54) Title of Invention

Printing of security documents

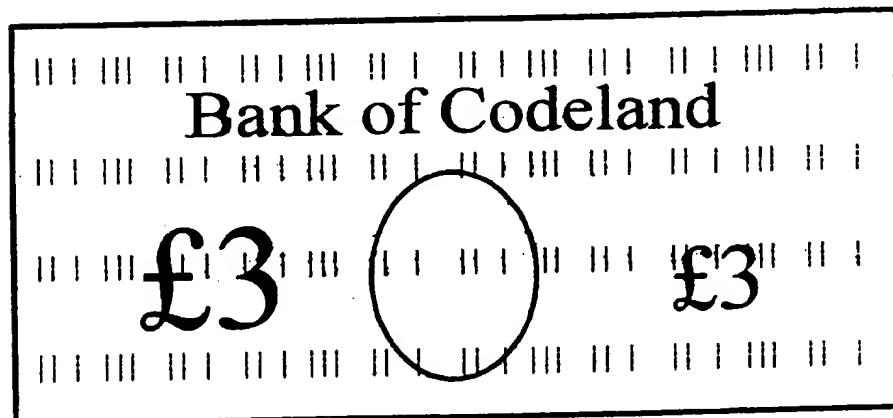
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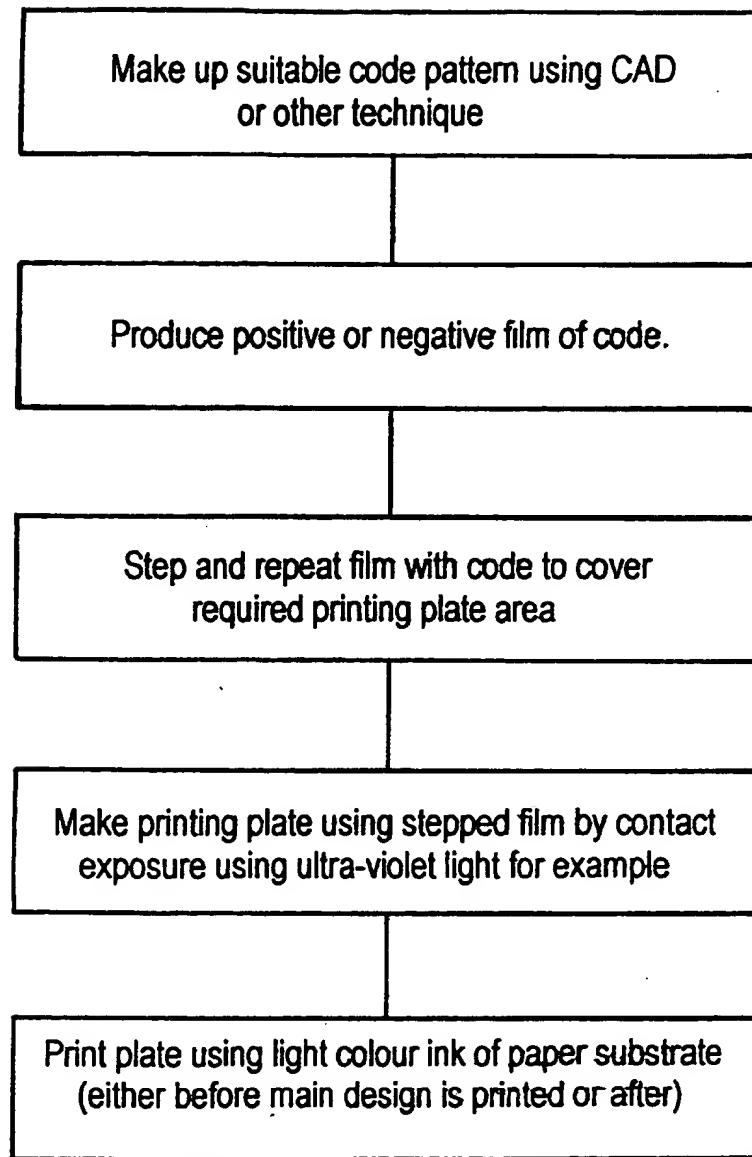
Substrate imaged with barcode in light colour

Fig. 1



Banknote image printed over coding

Fig. 2



Flow diagram of printing process

Fig.3

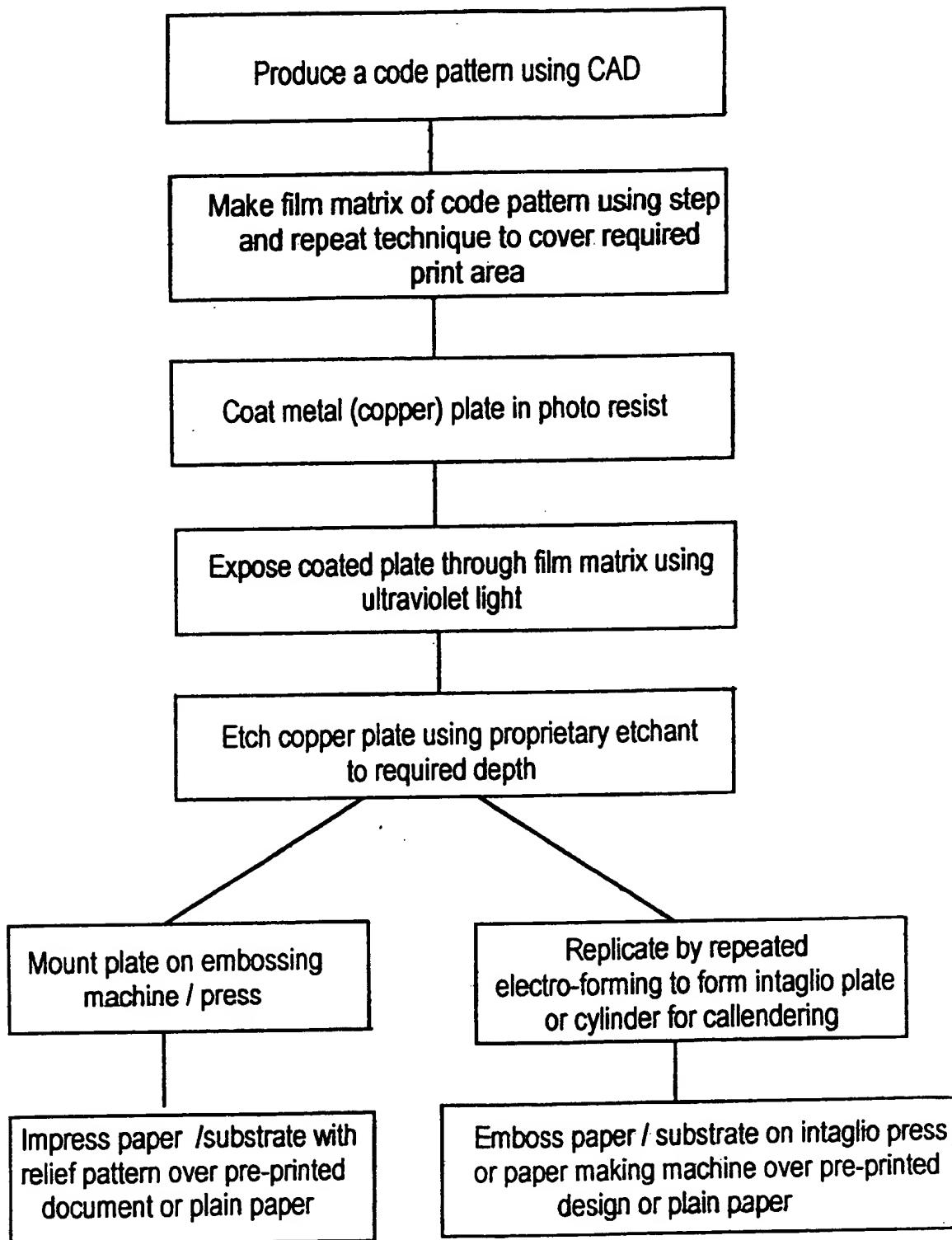
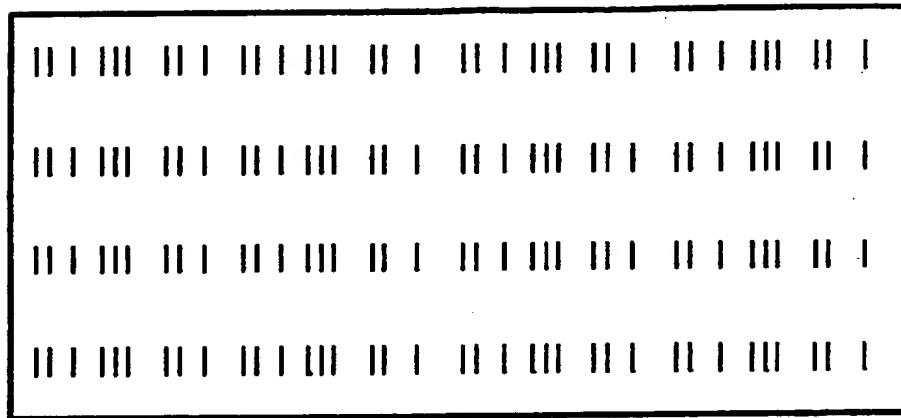
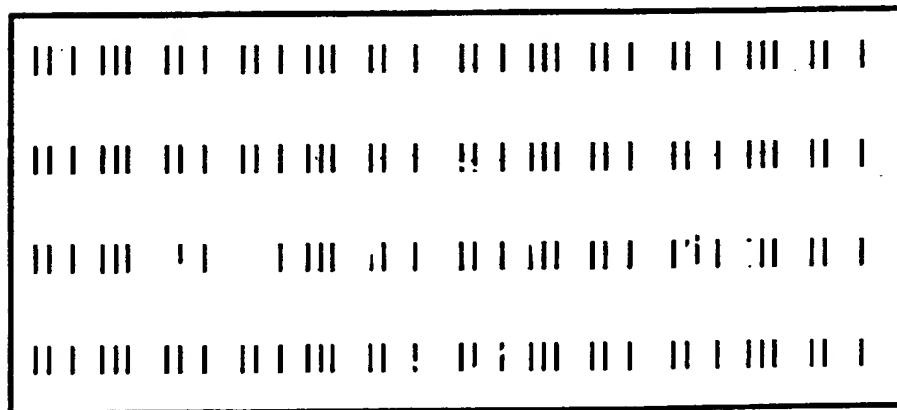


Fig. 4



Substrate imaged with barcode turned to
black by transforming pixels

Fig.5



Banknote image converted to 'white' to show code only

Fig.6

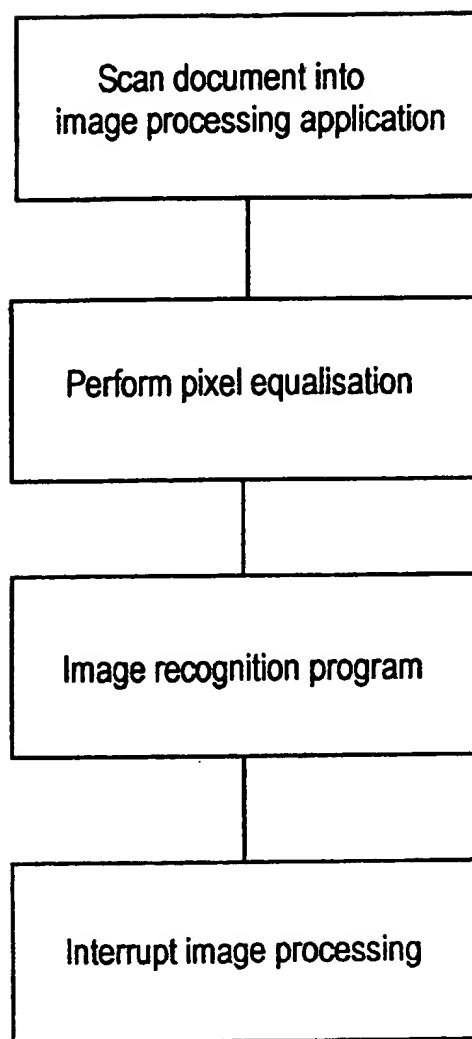


Fig. 7

Title: Printing of security documentsField of Invention

This invention concerns printing security documents and in particular to printing and encoding techniques which can be used to enable a data processor based imaging system to identify the presence of signals relating to security documents.

Background to the invention

It is known to scan a printed document and convert the image into digital data for feeding into a computer. A copy of the original document can be printed out using the image digital data using a laser jet or inkjet printer, and in this situation, the imaging device (usually a scanner), computer and printer, acts like a copier. The stored data can be edited or manipulated using graphics software so that the final print can be a very accurate reproduction of the original. Furthermore, the data can be transmitted for example via the internet or by modem and telephone line to a remote location, or stored for future use on a disk or other memory device, and this technology can be used to counterfeit security documents such as cheques, banknotes, identity documents and the like.

Prior art

Methods are known for modifying document substrates so that genuine substrates can be identified and distinguished from counterfeit substrates. Typically these methods include marking the genuine substrate with materials which fluoresce under ultra-violet, or which only emit light at some special region of the visible spectrum, or involve the addition of special material such as magnetic materials or infra-red absorbing pigments, or the inclusion of large scale water marking in pictorial or bar code form on or in the substrate. All these methods require either a gross alteration of the substrate (as in watermarking methods) or the inclusion of special materials usually requiring special detectors to

determine if the substrate of any document is genuine. Such methods tend to be expensive, the effects are usually readily visible to the naked eye, and it is not impossible to modify paper and other substrates in a similar manner, so as to confuse a verification process.

Object of the invention

It is an object of the present invention to provide a method of printing a security document with features which can be detected using a computer or other data processor based imaging system, but which are aesthetically undisturbing.

Summary of the invention

According to one aspect of the present invention a method of printing a security document to enable machine authentication thereof includes the step of incorporating a plurality of identification features within the printing of the document so that when illuminated and imaged onto a photosensitive device, image data signals are generated in the output of the device representative of the said features, characterised in that:

1. the contrast between the identification features and either the remainder of the substrate surface or the remainder of the printing in the regions containing the features, is selected so that image data signals corresponding to the features are substantially indistinguishable from image data signals relating to the substrate surface or surrounding image and/or from background noise signals; and are thereby indistinguishable by eye; and

2. the features are repeated in a pattern over at least some of the surface of the substrate so that during imaging the position of signals relating to each feature will bear at least one fixed relationship to signals relating to other of said features, and the pattern being such that a computing device supplied with the image data signals and programmed to perform image analysis with pattern recognition is able to determine whether identification feature signals bearing the said at least one fixed relationship are present in the data, whereby to generate a document identification signal if the identification feature signals are found in the image data signals.

The identification features may be spaced at regular intervals over the area of the substrate.

Each of the printed identification features may be similar in characteristic to each of the other identification features.

Documents of the same type may be printed with similar identification features having a similar fixed relationship over the surface of the document. Thus for example bank notes of one denomination may be printed having identification features of a particular type and a particular spacing unique to that denomination and currency.

The spacing may be selected so as to be constant in one direction only, or varied according to a special known pattern.

Similar or different spacings may be selected for identification features in other directions bearing a particular spatial relationship relative to the said first direction, for example perpendicular to the said first direction.

In a preferred example, the identification features are arranged in a 2D matrix over the substrate surface.

The existence of such printed identification features constitutes a primary encoding of the substrate, allowing substrates to be distinguished from printed substrates not containing such features, or to be distinguished one from another depending on the choice of features and/or spacing.

Secondary encoding of a substrate may be achieved by introducing variations into the matrix such as by omitting features from particular positions in such a regular matrix. Thus for example every fourth feature along each third line may be omitted.

Preferably secondary documents are encoded using both primary and secondary encodings.

In addition or alternatively secondary encoding may be provided if the matrix is formed from features having two characteristics and, instead of omitting features at specific positions within the matrix, features of one type are located at one set of positions in the matrix and features of the other type are located at other positions within the matrix. Thus in a simple example one set of features may be generally circular in shape, whereas interspersed features may have a different readily distinguishable shape such as rectangular or triangular shape.

Since the encoding of a printed substrate can be achieved by selecting the spacing between the printed identification features, or selecting features having a specific characteristic such as shape which can be identified in image data signals relating thereto, and/or by the substitution at selected points in a regularly occurring matrix of features having a different characteristic from the other features making up the matrix, and/or the omission of features at particular points in a matrix, there is an almost infinite number of possible combinations and permutations available to encode printed security documents.

Therefore not only does the invention permit a reliable method for identification of security documents, so as for example to readily detect forgeries which are not printed on an appropriate substrate, but each individual type of security document such as banknotes of different denominations, cheques originating from different banks, passports issued by different offices, and the like, if desired can be uniquely identified by a particular primary and/or secondary encoding of the printed material.

Image analysis techniques for identifying the presence of regularly occurring patterns and/or drop-outs within regularly occurring patterns and/or shape(s) or colour(s) or other visibly distinguishable features of detectable identification features in an image, are readily available and known, and by using high speed processors such as DSPs and the like, and the image data can be checked and verified, or otherwise, virtually instantaneously as printed documents are scanned.

More preferably if a secondary encoding is present, any variation on the primary encoding which constitutes the secondary encoding is even less capable of being distinguished by

the naked eye or picked up by a photosensitive device as used in a photocopier or document scanner.

Preferably the printed identification feature encoding is in the form of a repeat pattern.

The encoding or the pattern or both may be repeated at regular intervals in one or more directions across the document.

As the identification features are such that the appearance of the printed security document (for example a bank note) is not affected or disturbed aesthetically, authentic old security documents (especially bank notes) which do not contain the encoded features in the printed material, are able to be circulated in parallel with ones containing the encoding.

Two or more different encoding techniques using printed identification features may be combined in any document.

The substrate may have printed thereon a pattern using substantially transparent ink or ink whose colour is substantially the same as the colour of the substrate, so that when imaged and converted into image data signals, the latter which relate to the specially printed regions are virtually indistinguishable except for their particular relationship to other similar data signals, from image data signals relating to the remainder of the substrate surface.

Preferably the printed pattern is a repeat pattern, which extends over some or all of the surface of the substrate.

Where the printed pattern comprises a primary encoding and secondary encoding preferably produces multiple iterations of a code on the substrate.

The printed identification pattern may extend only within one or more selected printed areas of the document.

Redundancy created by multiple iterations can be used to advantage since the large number of similar iterations enhances the detectability of the features forming the code by increasing the effective signal to noise ratio. This facilitates the detection by data processing apparatus of the presence of an otherwise substantially invisible pattern of printed identification features.

For a document identification system to work, the encoding of the documents must be capable of being read for example by optically scanning the documents and generating image data signals which can be handled by a computer, or by using specialist imaging and signal analysing apparatus for performing this function.

It is a feature of the proposal that whilst any printed marking producing the coding of the documents can be read and detected using a suitably programmed data processing system, it is such as to be barely distinguishable to the naked eye and is also such that image data signals obtained from imaging and scanning the document will not contain data signals relating to the coded marking of sufficient magnitude to reproduce the coded marking features in any subsequent printing process using the data signals, if used for example to control a laser, inkjet or dye diffusion printer.

The invention also lies in a security document having a pattern of encoded identification features thereon produced by the aforesaid method, the pattern being such that image data signals representative of said pattern when the finished document is illuminated can be recognised by a computer supplied with the image data signals and programmed to perform image analysis with pattern recognition.

The invention also lies in a security document when printed as aforesaid.

A primary application of the invention lies in printing on the surface of a substrate encoding features which if detected during a scanning or copying process instigates a copying/printing corruption or inhibiting process. The detection step is performed as image data signals obtained by scanning a document and digitising the signals obtained and subjecting them to an algorithm.

The invention also provides a document identification method by which for recognition

purposes, a data processor can be programmed to look for one or more particular encodings which if detected in image data supplied to the processor as by imaging and scanning a document, will generate a document identification signal. This may be used for validating the imaged documents in the case of a bank note checking device, or inhibiting or otherwise interfering with the printing of a replica of the document in other cases.

The invention thus also provides a computer based document scanning device which can be used to identify the presence of a particular security document by checking that one or more patterns of one or more features are present in the document.

Thus for example, bank note authentication devices can be provided at relatively low cost to be associated with tills in shops, banks and post offices, so that at transaction points bank notes tendered by the public can be verified before they are accepted.

In the case of a currency note or similar, it may be of further interest to determine what denomination it is, and if more than one originating organisation is involved, it may also be advantageous to determine which organisation issued the note. Computer based document checking facilities of this type can be used as note accepters, can be used in note exchangers, and can be used to enable blind persons to discover what bank notes they have in their possession.

Description of different print encoding techniques

Any printing technique may be employed in general to produce a faint repeat pattern on the substrate such as a lithographic, dry offset, letterpress printing, inkjet printing or electrophotographic transfer of ink or toner.

In one technique a photographic master of the encoding is made in film such that the image is binary in nature. In other words it has clear areas for the "image" features and dark opaque areas for the "non-image" areas, or vice versa, and there are no "grey" areas. By this means the pattern is converted into a form suitable for making up into a printing plate.

A secondary encoding may be integrated into the printing by introducing variations into the image features and/or non-image areas of the photographic master, typically by altering electrical signals which are employed in the production of the photographic matter.

Using such a lithographic printing plate, the document substrate is first printed using a very light grey, yellow or brown ink which is very little different from the natural colour of the substrate itself, so that the pattern on the document is substantially invisible to the naked eye.

Alternatively the ink may be tinted. Some pigments such as reds, blues and greens may impart a colouration to the substrate and this may be desirable in some documents.

The term printing is also intended to cover any technique in which selected regions of a paper substrate are impregnated with fluid such as a resin or lacquer such that the optical absorption or reflectance characteristics or optical density of the substrate is altered sufficiently as between impregnated and non-impregnated regions as to be discernable under incident light during scanning for digitising, and the selected and remaining regions comprise a pattern which constitutes a primary encoding and variations in that pattern (such as edge, thickness and/or spacing variations) comprise a secondary encoding.

Additionally the surface of the substrate may be formed with features which produce different reflections of light than the remainder of the surface. Different surface treatments may be employed such as:

(1) Embossing

In a first technique embodying the invention, the substrate may be embossed during its manufacture. Thus it is customary in paper or sheet plastics manufacture to make the material smooth enough for printing by passing it through a high pressure nip between two steel rollers, a process known as calendering. By forming one or both of these rollers with indentations, a paper or plastics substrate forced therebetween, will be formed with

an embossing pattern corresponding to the indentations. By suitably encoding the embossed features, the substrate will be encoded as required by the invention, and can be detected by suitable illumination and converted into digital data signals by a scanner for analysis by a data processor.

(2) Surface treatment of lacquered papers

Where a paper or plastics substrate material has mixed therewith a resin or lacquer or other material to provide a smooth surface for printing, an encoded structure can be formed in the surface such that the actual surface of the substrate is sufficiently smooth to accept printing ink to enable a security document to be printed thereon, but at the same time contains a fine pattern of less smooth regions, which may be less receptive of printing ink.

(3) Impregnation

The surface may also be modified by a technique in which selected regions of a substrate describe a repeat pattern by being impregnated with a fluid such as a resin, or lacquer, such that the optical absorption or reflectance characteristics or optical density of the substrate is altered sufficiently as between impregnated and non-impregnated areas as to be discernable under incident light as during scanning for digitising.

(4) Laser treatment

The surface of the substrate can be etched by a laser beam, so as to produce cavities or grooves in the surface to be printed (or awaiting printing). This technique lends itself to the production of very fine patterns in the surface of the substrate and since a laser beam can be modulated very accurately can be used to introduce depth modulation in any such grooves or cavities as well as or instead of edge or thickness of spacing modulation.

(5) Watermarking

Watermarks alter the thickness and/or texture of a substrate, which variations and/or can be rendered visible under incident light and can be used to form primary and/or secondary encoding of the invention. They may be formed in two ways.

In the Fourdrinier paper making method, the wet paper is embossed using an embossing roller as it is being formed, thereby impacting a mark in the paper corresponding to the embossing. By forming the embossing in a suitable repeat pattern which extends over the area of the web, so the paper can be encoded with the watermark pattern.

A second technique for forming a watermark uses the so-called cylinder-mould method. In this method the watermark is formed by a cylindrical wire mesh on which is impressed "mouldings" in the form of images. During manufacture of the paper, fibres build up to a greater or lesser extent on the mesh moundings and where the thickness of the paper is greater, this gives a darker effect when viewed in transmission than do regions which are thinner and therefore which appear lighter when viewed in transmission. However where either types of watermark is just visible in incident light this can be used to provide the background coding required by the invention.

In accordance with the invention either watermarking technique may be employed to apply a pattern in the surface of a substrate especially a paper substrate, which is virtually imperceptible to the naked eye, but which will appear as a low contrast pattern when subjected to incident light as where a document is arranged for scanning and digitising.

The techniques so far described provide a surface encoded substrate which subsequently can be printed to form a security document. However some of the encoding techniques, eg embossing, may be applied after some or all of the printing of the document has occurred.

For example embossing may be applied after a title, or other text, or personal data for example in the case of an ID document has been printed onto a plain substrate, and a

surface encoding formed as a post-printing step.

Encoding by embossing can be achieved whilst printing at least some regions of a document. Thus the surface encoding may be imparted to the document by so-called "blind" intaglio printing, or intaglio printing with colourless ink. In such a method an image is printed using a plate containing engraved areas, some of which are filled with ink and some of which are left empty in the case of blind intaglio printing. The engraved plate, inked as appropriate, is pressed under high pressure against the substrate so as to cause the ink to transfer to the substrate. The substrate can become embossed with the engraved image, under the pressure applied, with parts of the substrate surface being printed, and others merely embossed.

Within the ambit of the invention, surface treatment of a substrate includes any technique which results in lighter and darker regions to be visible in the surface of a treated sheet of substrate when illuminated for scanning. Either or both primary and secondary encodings may be in the form of repeat pattern which are distinguishable under appropriate illumination to provide detectable content in digital signals obtained by scanning.

Encoding by embossing and printing may be achieved simultaneously. Thus the code may be imparted to the document by intaglio printing with substantially colourless ink. In such a method an image is printed using a plate containing engraved areas, which are filled with ink. The engraved plate is inked as appropriate and then pressed under high pressure against the substrate so as to cause the ink to transfer to the substrate. The substrate can become embossed with the engraved image, under the pressure applied, with parts printed and others left blank.

Description of Drawings

In the accompanying drawings:-

Figure 1 shows a banknote substrate imaged with barcode features in practice not discernable to the naked eye;

Figure 2 shows a banknote image printed over the substrate;

Figure 3 is a flow chart of the process for printing the barcode features on the banknote substrate;

Figure 4 is a flow chart of the process for embossing the barcode features on the substrate;

Figures 5 and 6 show images of the banknote revealed by a computer code extraction routine; and

Figure 7 is a flow chart of one possible deflection routine.

Description of Embodiment

Production

The process for printing the identification features on a banknote (or other security document) substrate will be clear from Figure 3 without further description. Analogously, an alternative process for embossing the identification features on the substrate will be clear from Figure 4.

The resulting substrate is shown in Figure 1, except that in practice the identification features, in this case a repetitive barcode pattern, would be invisible to the naked eye, whether printed or embossed.

The banknote is conventionally printed over the substrate and the result is shown in Figure 4. Since in practice the identification features are invisible to the naked eye, they are not aesthetically disturbing and do not affect the freedom of design of the banknote image. It is to be noted, however, that the banknote design may be printed either before or after the identification features are formed, either by printing (Figure 3) or by embossing (Figure 4).

Detection

There are various ways that computer based equipment can detect the aforesaid identification features and two such methods are described hereinafter.

The encoded document when scanned into a computer, is converted to a digital format. This typically means that the image is analysed into red, green and blue channels for each picture element or pixel. The colour of the picture element is assigned a value in each of these channels on a scale from 0 to 255 (8 bits) typically such that a full intensity is assigned to the value 255 and 'no colour' the value 0. Thus, bright white will be represented by all three channels having the value 255 and black by a zero intensity have the value 0.

When a real image, such as that of the printed banknote, is scanned into the system, most of the pixel values will lie in a central region between say, 230 for the paper background and 40 for the darkest print. The pixels relating to the low contrast encoding would be within a band very close to the paper background values. Assume, for example, that the encoding is such that it is printed in a controlled way so that it is always within a band of 20 pixel values of the paper background.

It is a simple matter for a computer program to reset all values between a value just below that of the paper (in this example, say 228) and the bottom of the values relating to the encoding band (in this example say, 210) to a value of 10, or even zero, (near black) and to reset all other values between 210 and 0 in this example to 230 (in other words the same colour as the paper background).

This procedure has the effect of eliminating all the printed design features except the encoding and those very weak features associated with the design, which are usually very few in number since they cannot be easily seen and would not therefore be included in the design for aesthetic reasons. The encoding itself would by this procedure now be rendered black (see Figure 5) so that it can be read by a program especially designed to recognise the coding. As a simple example, if the coding were a series of Alphanumeric characters

such as letters and numbers, an optical character recognition program could be used to read the data and determine if it was likely to be a known code. Alternatively, more sophisticated image detection techniques could be used, especially if the coding were of a more complex type such as that used in digital watermarking for example. In some cases, it may be preferred in order to show the encoding only (Figure 6).

Alternatively, the encoding could be extracted using a contrast enhancement routine such as is commonly known as 'equalisation'. This is shown in Figure 7. This type of routine sets the maximum value of the pixels in each channel to 255 and the minimum value to 0 and then attempts to smoothly redistribute the intervening pixel values between the two. This has the effect of increasing the difference between the pixel values close to the paper background and thus those relating to the code so that they are easier to recognise in an image recognition program or routine. This method has the disadvantage that other design features unrelated to the code are still present and need to be disregarded by the recognition routine.

However, more sophisticated routines, can be used which recognise complex encoding patterns such as those used for high-level codes in complex images and patterns.

Claims

1. A method of printing a security document to enable machine authentication thereof includes the step of incorporating a plurality of identification features within the printing of the document so that when illuminated and imaged onto a photosensitive device, image data signals are generated in the output of the device representative of the said features, characterised in that:
 - (i) the contrast between the identification features and either the remainder of the document substrate surface or the remainder of the printing in the regions containing the features, is selected so that image data signals corresponding to the features are substantially indistinguishable from image data signals relating to the substrate surface or surrounding image and/or from background noise signals; and are thereby indistinguishable by eye; and
 - (ii) the features are repeated in a pattern over at least some of the surface of the substrate so that during imaging the position of signals relating to each feature will bear at least one fixed relationship to signals relating to other of said features, and the pattern being such that a computing device supplied with the image data signals and programmed to perform image analysis with pattern recognition is able to determine whether identification feature signals bearing the said at least one fixed relationship are present in the data, whereby to generate a document identification signal if the identification feature signals are found in the image data signals.
2. A method according to claim 1, wherein the identification features are spaced at regular intervals over the area of the substrate.
3. A method according to claim 1 or claim 2, wherein each of the printed identification features is similar in characteristic to each of the other identification features.
4. A method according to any of claims 1 to 3, wherein the spacing of identification features is selected so as to be constant in one direction only, or varied according to a

predetermined pattern, and similar or different spacings are selected for identification features in other directions bearing a particular spatial relationship relative to the said first direction, for example perpendicular to the said first direction.

5. A method according to any of claims 1 to 4, wherein the identification features are arranged in a 2D matrix over the substrate surface.

6. A method according to claim 5, wherein secondary encoding of a substrate is achieved by introducing variations into the matrix such as by omitting features from particular positions in a regular matrix.

7. A method according to claim 5, wherein the matrix is formed from features having two characteristics and features of one type are located at one set of positions in the matrix and features of the other type are located at other positions within the matrix.

8. A method according to any of claims 1 to 7, wherein two or more different encoding techniques using printed identification features are combined in the substrate.

9. A method according to any of claims 1 to 8, wherein the substrate has printed thereon a pattern using substantially transparent ink or ink whose colour is substantially the same as the colour of the substrate, so that when imaged and converted into image data signals, the latter which relate to the specially printed regions are virtually indistinguishable except for their particular relationship to other similar data signals, from image data signals relating to the remainder of the substrate surface.

10. A method according to claim 9, wherein the printed pattern is a repeat pattern, which extends over some or all of the surface of the substrate.

11. A method according to claim 9 or claim 10, wherein the printed pattern comprises a primary encoding and secondary encoding preferably produces multiple iterations of a code on the substrate.

12. A method according to any of claims 9 to 11, wherein the printed identification pattern extends only within one or more selected printed areas of the document.

13. A method according to any of claims 1 to 12, wherein a printing technique is employed to produce a faint repeat pattern of the identification feature on the substrate, such as a lithographic, dry offset, letterpress printing, inkjet printing or electrophotographic transfer of ink or toner.

13. A method according to any of claims 1 to 12, wherein a printing technique is employed to produce a faint repeat pattern of the identification feature on the substrate, such as a lithographic, dry offset, letterpress printing, inkjet printing or electrophotographic transfer of ink or toner.

14. A method according to claim 13, wherein a secondary encoding is integrated into the printing by introducing variations into the image features and/or non-image areas of a photographic master, typically by altering electrical signals which are employed in the production of the photographic matter.

15. A method according to claim 13 or claim 14, wherein using such a lithographic printing plate, the document substrate is first printed using a very light tinted grey, yellow or brown ink which is very little different from the natural colour of the substrate itself, so that the pattern of identification features on the document is substantially invisible to the naked eye.

16. A method according to any of claims 1 to 15, wherein the surface of the substrate is physically formed with features which produce different reflections of light than the remainder of the surface.

17. A method according to claim 16, wherein the substrate is embossed during its manufacture to form the identification features.

18. A method according to claim 16, wherein a paper or plastics substrate material has

mixed therewith a resin or lacquer or other material to provide a smooth surface for printing and an encoded structure is formed in the surface such that the actual surface of the substrate is sufficiently smooth to accept printing ink to enable a security document to be printed thereon, but at the same time contains a fine pattern of less smooth regions, which are less receptive of printing ink.

19. A method according to claim 16, wherein the substrate surface is be modified by a technique in which selected regions of a substrate describe a repeat identification pattern by being impregnated with a fluid such as a resin, or lacquer, such that the optical absorbtion or reflectance characteristics or optical density of the substrate is altered sufficiently as between impregnated and non-impregnated areas as to be discernable under incident light.
20. A method according to claim 16, wherein the surface of the substrate is etched by a laser beam, so as to produce identification features in the form of cavities or grooves in the surface to be printed (or awaiting printing).
21. A method according to claim 16, wherein watermarking is used to vary the thickness and/or texture of a substrate, which variations and/or can be rendered visible under incident light and are used to form the primary and/or secondary encoding.
22. A security document substrate having encoded identification features thereon produced by the method of any of claims 1 to 21, the pattern being such that image data signals representative of said pattern when the finished document is illuminated can be recognised by a computer supplied with the image data signals and programmed to perform image analysis with pattern recognition.
23. A security document when printed with a design superimposed on the document substrate of claim 22.
24. An identification method for the document of claim 23, wherein for recognition purposes, a data processor is programmed to look for one or more particular encodings which if detected in image data supplied to the processor, as by imaging and scanning a document, will generate a document identification signal.
25. A method according to claim 24, when used for validating the imaged documents in the

25. A method according to claim 24, when used for validating the imaged documents in the case of a bank note checking device, or inhibiting or otherwise interfering with the printing of a replica of the document in other cases.

